

INDUCTIVE POWER ADAPTER

Cross-Reference to Related Applications

- [01] The present application is related to Application Serial No. 10/*** (Atty. Docket No. 003797.00690), entitled “Inductively Charged Battery Pack,” and filed on December 12, 2003; which is related to Application Serial No.10/*** (Atty. Docket No. 003797.00692), entitled “Inductive Battery Charger,” and filed on December 12, 2003, each of which is incorporated by reference herein as to their entireties.

Field of the Invention

- [02] Aspects of the present invention relate to power supplies for electronic apparatus. More particularly, aspects of the present invention pertain to an inductive power adapter for receiving inductive energy to power electronic apparatus.

Background of the Invention

- [03] Computer systems have become increasingly popular in modern society. Conventional computer systems, especially computer systems using graphical user interface (GUI) systems, accept user input from a conventional input device, such as a keyboard for entering text, and a pointing device, such as a mouse for operating the graphical user interface. The processing capabilities of computers have increased the efficiency and productivity of workers in a wide range of professions. Marketing staff, corporate executives, professionals and others use mobile computers to easily transport their data and work with computers out of the office or on travel.
- [04] The popularity of portable electronic devices allow users to work and play free of restrictive power cords and chargers for a limited period of time. As people work outside of their traditional office, they often find themselves using their notebook computers, cellular phones, digital assistants and tablet computers. Similarly, people enjoying themselves away from the home take advantage of portable music players, digital

cameras, electronic game systems and the like while on travel or doing outdoors activities.

[05] Rechargeable batteries are used for portable electronic devices, such as portable computing systems, video cameras, and mobile phones. While users attempt to operate with the freedom of mobile computing, there are still basically tethered to the power cable. The users must think about how much power is available for mobile use. This time period is limited to the type of battery and other factors. Users often carry power cables and AC power adapters with them so they can physically connect to electronic power for recharging when the battery power gets too low. These users must search for electrical plug locations that may be in inconvenient places and potentially create risk hazards for other people who might walk into the power cords. Still at other times, the user may fumble with various types of power connectors for the specific electronic device. Additionally, users often carry supplemental power adapters to replace the depleted energy of the battery. Besides the general inconvenience of carrying additional power adapters, these actions create additional problems, including wasting space in cases and increasing the weight load a user must carry. Thus, the mobile computing user still does not receive the freedom of portable computing.

[06] To replace rechargeable batteries, a contactless power supply may be used in commercial aircraft. In one example, U.S. Patent No. 6,489,745 to Kories describes a contactless power supply for a laptop computer with a seatback tray of a commercial aircraft. This patent is incorporated by reference. The power supply of Kories has several drawbacks. There is no active communication between the power supply and the seatback. Unwanted flux could be sent to metallic objects. Further, the system of Kories would damage current mobile device designs and does not allow for device independence for powering.

[07] In view of the foregoing, what is needed is an apparatus and method to support user interaction for an untethered environment for the new media technologies and productivity activities for mobile electronic devices.

Summary of the Invention

- [08] Aspects of the present invention provide inductive power arrangements enabling user convenience in wireless power environments for mobile devices and communications devices. An inductive power system transfers energy by inductively coupling a source coil on a power source to a receiver coil on a power adapter. Aspects of the present invention enable communication between a power source and the power adapter which maximizes the flexibility, efficiency or safety of the inductive power arrangements. Aspects of the present invention provide for wirelessly communicating operating parameters between a source and a power adapter. A wireless communication arrangement may also provide for authentication of devices that are allowed by the source to be powered.
- [09] The above and other aspects, features and advantages of the present invention will be readily apparent and fully understood from the following detailed description illustrative embodiments in conjunction with the accompanying drawings, which are included by way of example, and not by way of limitation with regard to the claimed invention.

Brief Description of the Drawings

- [10] Figure 1 is a functional block diagram of an illustrative general-purpose digital computing environment in which one or more aspects of the present invention may be implemented;
- [11] Figure 2 is a schematic representation diagram of a pen-computing system according to one or more aspects of the present invention;
- [12] Figure 3 is a functional block diagram of an illustrative inductive power system according to one or more aspects of the present invention;
- [13] Figure 4 is a block diagram of an illustrative data structure according to one or more aspects of the present invention;

- [14] Figure 5 is a flow diagram of a first illustrative powering process according to one or more aspects of the present invention;
- [15] Figure 6 is a flow diagram of a second illustrative powering process according to one or more aspects of the present invention;
- [16] Figure 7 is a functional block diagram of an alternative inductive power system according to one or more aspects of the present invention;
- [17] Figure 8 is a schematic representation diagram of an inductive power system according to one or more aspects of the present invention; and
- [18] Figure 9 is a plan schematic view of an alternative inductive power source according to one or more aspects of the present invention.

Detailed Description of the Invention

- [19] The following description is divided into sub-sections to assist the reader. The subsections include Overview; Illustrative Host Operating Environment; System Environment; Illustrative Data Structure; Illustrative Operating Environment; and Alternative Systems.

Overview

- [20] Aspects of the present invention provide inductive power arrangement enabling user convenience in wireless power environments for mobile computing and mobile communications devices. An inductive power system transfers energy by inductively coupling a source coil on a power source to a receiver coil of an inductive power adapter. Current flows through the source coil and the resulting magnetic flux induces an alternating current through the magnetic field and across the receiver coil, completing an energy transfer circuit. The source AC current is received in the power adapter and converted to direct current for transfer to a connected host device. Aspects of the present invention enable communication between an inductive power source and the power

adapter which maximizes the flexibility, efficiency or safety of the inductive power solutions. Aspects of the present invention provide for wirelessly communicating operating parameters. A wireless communication arrangement may also provide for authentication of devices that are allowed by the source to receive power.

- [21] In an illustrative aspect, a smart inductive power system may include a chargepad or powerdock and a smart power adapter unit within a device in need of power. The powerdock may listen for devices needing power within proximity of at least some of its energy transfer coils. A device equipped with the smart power adapter in range of the powerdock may wirelessly negotiate and transmit power requirements, such as maximum charge rate. Once the negotiation is complete, the powerdock may energize its coils closest to the smart power adapter and inductively transfer power to the device in accordance with device requirements. This solves several safety drawbacks associated with high field inductive power systems and promotes the use of sophisticated mobile electronics with varying power requirements serviceable through a common chargepad or powerdock. Additionally, the inductive power adapter solution provides a method for existing mobile devices to take advantage of inductive power sources without modification to the device or its battery pack.
- [22] In an illustrative aspect, an apparatus transmits inductive energy to a power adapter. The power adapter may include a microprocessor for processing data relevant to the inductive energy. A memory may be provided in the apparatus for storing computer readable instructions relevant to the power adapter. A processor unit may be operatively coupled to the memory. A transmission element in the apparatus may be operatively coupled to the processor so as to provide the inductive energy to the power adapter.
- [23] In another illustrative aspect, an adapter apparatus may be configured for receiving inductive energy. The adapter may include a processor unit for processing computer readable data relevant to the inductive energy and for processing data communications with a computer system. A coil may be configured for receiving the inductive energy. A power supply may be operatively coupled to the processor unit and the coil. Ann the

power supply may be configured to output a direct current responsive to the inductive energy.

- [24] In an illustrative aspect, a computer system may be configured to operate with a power adapter. The computer system may include a processor, a display coupled to the processor, and a memory coupled to the processor. The memory is configured to store computer executable instruction that cause that the computer system to perform the steps of receiving an event relevant to an inductively powering a power adapter and adjusting a portion of the display to indicate the event. The adjusting feature may include displaying a graphical object on the display in which the graphical object can be icon and the like.
- [25] In an illustrative aspect, a computer implemented method is provided for powering a power adapter. A polling message is received from a source. A request for power message is transmitted to the source. And inductive power is received from a source. In another aspect, authenticating data can be transmitted to the source. Thus, a power adapter can receive electrical power through a trusted arrangement.

Illustrative Host Operating Environment

- [26] Various aspects of the present invention may at least be described in the general context of apparatus and computer-executable instructions, such as program modules, executed by one or more computers or other devices. Accordingly, it may be helpful to briefly discuss the components and operation of a general purpose computing environment on which various aspects of the present invention may be implemented. A host device system 100 can be used for processing data and communicating with a power adapter 304(See FIG. 3). Such an illustrative host system environment is shown in Figure 1.
- [27] Accordingly, Figure 1 illustrates a schematic diagram of an illustrative general-purpose digital computing environment that may be used to implement various aspects of the present invention. In Figure 1, a computer 100 includes a processing unit 110, a system memory 120, and a system bus 130 that couples various system components including the system memory to the processing unit 110. The system bus 130 may be any of several

types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. The system memory 120 includes read only memory (ROM) 140 and random access memory (RAM) 150.

[28] A basic input/output system 160 (BIOS), containing the basic routines that help to transfer information between elements within the computer 100, such as during start-up, is stored in the ROM 140. The computer 100 also includes a hard disk drive 170 for reading from and writing to a hard disk (not shown), a magnetic disk drive 180 for reading from or writing to a removable magnetic disk 190, and an optical disk drive 191 for reading from or writing to a removable optical disk 192, such as a CD ROM or other optical media. The hard disk drive 170, magnetic disk drive 180, and optical disk drive 191 are connected to the system bus 130 by a hard disk drive interface 192, a magnetic disk drive interface 193, and an optical disk drive interface 194, respectively. The drives and their associated computer-readable media provide nonvolatile storage of computer readable instructions, data structures, program modules, and other data for the personal computer 100. It will be appreciated by those skilled in the art that other types of computer readable media that may store data that is accessible by a computer, such as magnetic cassettes, flash memory cards, digital video disks, Bernoulli cartridges, compact flash cards, smart media, random access memories (RAMs), read only memories (ROMs), and the like, may also be used in the example operating environment.

[29] A number of program modules may be stored on the hard disk drive 170, magnetic disk 190, optical disk 192, ROM 140, or RAM 150, including an operating system 195, one or more application programs 196, other program modules 197, and program data 198. A user may enter commands and information into the computer 100 through input devices, such as a keyboard 101 and a pointing device 102. Other input devices (not shown) may include a microphone, joystick, game pad, satellite dish, scanner, or the like. These and other input devices often are connected to the processing unit 110 through a serial port interface 106 that is coupled to the system bus 130, but may be connected by other interfaces, such as a parallel port, game port, or a universal serial bus (USB). Further still, these devices may be coupled directly to the system bus 130 via an appropriate

interface (not shown). A monitor 107 or other type of display device is also connected to the system bus 130 via an interface, such as a video adapter 108.

- [30] In addition to the monitor 107, personal computers typically include other peripheral output devices (not shown), such as speakers and printers. As one example, a pen digitizer 165 and accompanying pen or user input device 166 are provided in order to digitally capture freehand input. The pen digitizer 165 may be coupled to the processing unit 110 via the serial port interface 106 and the system bus 130, as shown in Figure 1, or through any other suitable connection. Furthermore, although the digitizer 165 is shown apart from the monitor 107, the usable input area of the digitizer 165 may be co-extensive with the display area of the monitor 107. Further still, the digitizer 165 may be integrated in the monitor 107, or may exist as a separate device overlaying or otherwise appended to the monitor 107.
- [31] The computer 100 may operate in a networked environment using logical connections to one or more remote computers, such as a remote computer 109. The remote computer 109 may be a server, a router, a network PC, a peer device, or other common network node, and typically includes many or all of the elements described above relative to the computer 100, although only a memory storage device 111 with related applications programs 196 have been illustrated in Figure 1. The logical connections depicted in Figure 1 include a local area network (LAN) 112 and a wide area network (WAN) 113. Such networking environments are commonplace in offices, enterprise-wide computer networks, intranets, and the Internet.
- [32] When used in a LAN networking environment, the computer 100 is connected to the local network 112 through a network interface or adapter 114. When used in a WAN networking environment, the personal computer 100 typically includes a modem 115 or other means for establishing a communications link over the wide area network 113, *e.g.*, to the Internet. The modem 115, which may be internal or external, is connected to the system bus 130 via the serial port interface 106. In a networked environment, program

modules depicted relative to the personal computer 100, or portions thereof, may be stored in a remote memory storage device.

[33] It will be appreciated that the network connections shown are illustrative and other techniques for establishing a communications link between the computers may be used. The existence of any of various well-known protocols such as TCP/IP, Ethernet, FTP, HTTP and the like is presumed, and the system may be operated in a client-server configuration to permit a user to retrieve web pages from a web-based server. Any of various conventional web browsers may be used to display and manipulate data on web pages.

[34] Figure 2 illustrates a mobile pen-based computing system 201 that may be used in accordance with various aspects of the present invention. Any or all of the features, subsystems, and functions in the system of Figure 1 may be included in the computing system of Figure 2. Pen-based computing system 201 includes a display surface 202, e.g., a digitizing flat panel display, such as a liquid crystal display (LCD) screen, on which a plurality of windows 203 is displayed.

System Environment

[35] Inductive power system arrangements in accordance with one or more aspects of the present invention are shown in FIGS. 3-9. Referring to FIG. 3, an inductive power system 300 may include an inductive power source 302 that wirelessly provides electrical power to an inductive power adapter 304. The inductive power adapter 304 may be physically connected to the host device 100 while being powered by the inductive power source 302. The host device 100 need not be aware of the inductive power source. The inductive power adapter 304 may include a housing for enclosing the electrical components therein. The adapter 304 housing may be provided in any appropriate shape and may fit into a battery port of typical portable electronic devices. Thus, the power adapter is able to work with virtually any portable electronic device that is adapted to

operate with electric battery power, such as mobile computers, personnel digital assistants, cellular phones and the like.

- [36] Referring to FIG. 3, the inductive power source 302 may be electrically connected to an alternating current power source, such as utility electrical power and the like. In such an arrangement, inductive power source 302 may include a power supply 306 that receives electric energy via the conventional method of a cord physically coupled to a standard wall electrical outlet (not shown) for 60 Hz, 120 volt power, or alternatively, 50 Hz at 230 volts and other frequency/voltage combinations. The inductive power source 302 may include one or more power transmission coils 312 operatively coupled to the power supply 306. The operative coupling may include any form of network connection including physical wiring and/or logical connections, and the like.
- [37] The power adapter 304 may be configured to receive electrical energy from inductive source 302. In one arrangement shown in Figure 3, power adapter 304 includes a power pickup coil 324 that is operatively coupled to a power supply 320. Power pickup coil 324 receives inductive energy from the power transmission coil 312 of inductive source 302. The power supply 320 of power adapter 304 provides electrical energy to the host device 100 via a power port or communications bus 328. The power supply 320 may convert the AC current to direct current for use with the host device 100.
- [38] In one arrangement, power supply 306 of inductive power source 302 may be configured to convert the frequency of the alternating line current from 50/60 Hz to a higher frequency for inductively transferring energy from the power transmission coil 312 to the power pickup coil 324 of power adapter 304. The power supply 320 of power adapter 304 may be configured receive the transmission frequency. The specific frequencies of transmission can be varied, i.e. for instance within the range of 500Hz to 10KHz. Nevertheless, other frequencies can be used. In one operation, power adapter 304 may be brought proximate or juxtaposed to the inductive power source 302. The power transmission coil 312 of the power source 302 and the power pickup coil 324 of the

power adapter 304 are then inductively coupled by an alternating current at any appropriate frequency to transfer the electrical power.

[39] The inductive power source 302 may include a microprocessor controller 308. Likewise, the power adapter 304 may also include a microprocessor controller 316. The controller 308 may be configured for controlling the power supply 306 for different modes of operation, processing and storing data. Likewise, controller 316 may be configured for modes of operation, receiving, transmitting and storing data and performing mathematic calculations to provide power to host device 100. Additionally, controller 308 and controller 316 are enabled to have features of authentication and security. Controller 308 and controller 316 may have computer-readable media 415 (see FIG.4), which provides nonvolatile storage of computer readable instructions, data structures, program modules, and other data relevant for power operations. Other examples of computer-readable media include flash memory, random access memories (RAMs), read only memories (ROMs), and the like. The controller 316 may also include an integrated analog to digital converter (not shown) for monitoring environmental parameters of the power supply, such as temperature, voltage and current. In such an arrangement, the appropriate analog sensing devices may be used (not shown).

[40] In one arrangement, controller 316 may be implemented with one or more features of a system management bus configuration. It is believed these features have not been implemented before for inductive power arrangement or inductive power adapters. For example, the communication bus 328 may be configured as a system management bus (SMBus). The System Management Bus can be used to inform a data processing system, such as host device 100 or computer 201, as to a wide range of information about the power adapter 304, e.g., current, and voltage. In the case of inductive power adapter 304, no charging battery is needed within the adapter. The SMBus is a two-wire interface system through which a processor within a power adapter 304 can bi-directional communicate with the rest of a computer system, such as host device 100. One wire handles the data transfer and the second wire is the clock. Controller 316 may contain computer readable data programmed by the manufacturer, such as a power adapter ID

number, serial number, manufacturer's name and date of manufacture. This data can be used by the inductive power source 302 for novel power operations according to aspects of the present invention. If desired, controller 308 may be implemented with one or more features of system management bus. An example a system management bus appears to in the system management bus specification revision 2.0 standard available from the SBS Implementers Forum.

- [41] In an alternative arrangement shown in FIG. 3, the power supply 320 can provide direct current as an output to the host device 100, and the power supply 320 may be operable as an SMBus device. In this arrangement, power supply 320 may be in logical communications with host device 100, or controller 316. In one example, power supply 320 can be enabled to perform events to the host device 100 with regard to inductive power. Nonetheless, controller 316 as a SMbus operable device can provide an event as well, with regard to inductive power. In another example, host device 100 can be configured to receive any or all of the data programmed into the controller 316, or from a separate memory 415(see FIG. 4). The data may include power adapter ID number, serial number, manufacturer's name, or date of manufacture associated with the power adapter 304. This data can be used by the host device 100 for various operations such as, for display, data security, or configuration of the adapter 304 and the like. Alternatively, the inductive power source 302 may include components therein configured as SMBus devices. For example, power supply 306, controller 308, or modem 310 may be SMBus operable devices. It will be appreciated that the connections shown in FIG. 3 are illustrative and other applicable techniques for establishing a communications link between the components may be used. For example, the connections shown in FIG. 3 between the controller 316 and power supply 320; between the controller 316 and host device 100; and between the power supply 320 and host device 100 are illustrative and other techniques for establishing a communications link between the components may be used.
- [42] In one arrangement shown in FIG. 3, the inductive power source 302 and the power adapter 304 may be configured for wireless data communications. The inductive power

source 302 may include a communication device 310, such as a modem or network interface device. Likewise, the power adapter 304 may also include communications device 318, such as a modem or network interface device. For ease of explanation, the communication device is referred herein to as a modem. The modem 310, 318 may be configured for power line carrier communications. In such a configuration, modem 310, 318 are operatively coupled to the respective coils 312, 324. Modem 310, 318 may be adapted to modulate and demodulate signals appropriate to the frequency supplied by the power supply 306, 320 to receive and transmit data. Thus, the power transmission coil 312 of the power source 302 and the power pickup coil 324 of power adapter 304 are used to provide inductive data communications over an inductive pathway. In one arrangement, the modems 310, 318 may be implemented with power line networking technology in accordance with the HOMEPLUG 1.0 Standard Specification available from the Homplug Powerline Alliance located at San Ramon, CA, USA. For example, under a homeplug implementation, the modems may use a burst mode form of orthogonal frequency-division (OFDM) multiplexing with a forward error-correction scheme. OFDM is a well known technique in industry. The media access (MAC) protocol in a homeplug configuration is based on the well-known carrier sense multiple access with collision avoidance (CSMA/CA) protocol. Rates of data transfer can be upwards of 14 Mbps, if desired. Nevertheless, a wide range of other well-known power line networking technologies could be used, such as X-10 protocol and frequency-shift keying schemes used for internetworking within homes via the power lines. Advantageously, power adapter 304 and inductive power source 302 can be electrically coupled for wireless energy transfer functionality and data communications to wirelessly communicate operating parameters, such as voltage or maximum expected power consumption and the like.

Illustrative Data Structure

- [43] Figure 4 illustrates an example schematic diagram of a data structure 400 which can be transmitted between the modems 310, 318. Data structure 400 may include an address

402, a header 404, and a payload 406. Address 402 includes data for the specific power adapter being charged. This is useful in multiple power adapter environments because different power adapters can have different power requirements for the host device being served. The header 404 includes general data to be used by the controller 308, controller 316, and modems 310, 318. The payload 406 contents specific data to be used by the controllers relevant to the power operation. Such data would include operating parameters, such as voltage and maximum expected power consumption. Nevertheless, the payload 406 may include other data, such as authentication information. Data structure 400 may be implemented with well-known powerline networking technology and/or encapsulated in another structure of packets for transmission, such as Bluetooth protocol, homeplug, or X-10 protocols and the like.

Illustrative Operational Environment

- [44] In one arrangement, controller 316 may contain computer readable data programmed by the manufacturer or other entity, such as a power adapter ID number, serial number, manufacturer's name and/or date of manufacture. Various aspect of the noted data may be used by the inductive power source 302 for novel power operations according to aspects of the present invention, such as shown in FIGS. 5 and 6.
- [45] Figure 5 illustrates an example communications powering process according to one or more aspects of the present invention that enables communication between a power source and the inductive power adapter. Various aspects of the present invention may at least be described in the general context of apparatus and computer-executable instructions, such as program modules, executed by one or more computers or other devices, such as microprocessors. For example, controller 308 and controller 316 may have computer-readable media 415, which provides nonvolatile storage of computer readable instructions, data structures, program modules, and other data relevant for charging operations. In one arrangement, inductive power source 302 and inductive power adapter 304 may be configured for wireless data communications as well as

energy transfer. Accordingly, inductive power source 302 may be configured to poll for other devices, such as the power adapter 304.

- [46] In FIG. 5, steps 500-510 illustrate a negotiation process in which communications and power requirements can be established between the inductive power source 302 and the inductive power adapter 304. To start the process, in step 500, the inductive power source 302, in a low power or broadcast mode, polls for compatible devices through one or more of the power transmission coils 312 and listens for replies from the devices, such as power adapter 304. In a polling operation, power transmission coil 312 can be energized and de-energized in a regular periodic fashion. For example, the energizing and de-energizing period range between any appropriate value, such as 100-1000 ms, or 1-60 sec. This periodic arrangement can conserve energy. It should be recognized that the controller 308 generates communication signals in the source 302 and the signals are converted for power line modulation by the modem 308. The communication signals are routed from the modem 308 to the power transmission coil 312 for transmission to the power pickup coil 324.
- [47] In step 502, the power adapter 304 has at least a listening mode and a power receiving mode. In the listening mode, the power adapter 304, via controller 316, is configured to listen for a power source through the power pickup coil 324. In generally, the power adapter 304 may be brought a proximate distance to the inductive power source 302. Once the transmission coil 312 and pickup coil 324 are in close enough proximity to establish communications and inductive coupling, the power supply 320 can generate sufficient current to power the controller 316 and modem 318, the communication signals received by the pickup coil 324 are de-modulated by the modem 308 and routed to the controller 316 of power adapter 304. Of course, the communication signals may be the type as referenced with data structure 400(See FIG. 4).
- [48] In step 504, the power adapter 304, via controller 316, may respond to the source 302 poll with a message requesting that power be supplied thereof. In step 506, upon receiving the power adapter's request for power, the source 302 may request information

or power parameters from the power adapter 304, such as the required voltage and maximum power requirement. Nevertheless, the inductive power source 302 can request other information relevant to the power adapter 304, such as a power adapter ID number, and serial number and the like. This information can be used for security, data integrity, or other purposes. In step 508, the power adapter 304 transmits the requested information. In step 510, the source 302, via controller 308, determines if it can supply the requested voltage and power to the power adapter 304. In step 512, if the source 302 cannot supply the requested voltage and/or power, then the source 302 can change to the polling mode. Alternatively, if the source 302 can provide the voltage and/or power, then the process flows to step 514 for the powering receiving mode.

[49] After the negotiation process, optionally, in step 516, when the power adapter 304 is receiving power from inductive power source 302, the controller 316 may report to the host device 100, via the communications bus 328, that it is receiving external power and the power state. In one case, the controller 316 can report that the external power is from an inductive power source, rather than a standard utility power. In such arrangement, a visual indication of the inductive power arrangement may be provided in the form of a graphical icon configured to operate with an appropriate event-driven operating system or in an SMBus arrangement. Thus, a graphical user interface can have a display portion relevant to the type of power being received, e.g., inductive power. In the context of the present invention, a displayed “object” may include text, graphics, and other related elements for a display, such as monitor 107 or display surface 202(See FIGS. 1 and 2, respectively). When power from the source is lost, the power adapter returns to its listening mode.

[50] Figure 6 illustrates an example communication powering process according to one or more aspects of the present invention to enable communication between a power source and the power adapter. In one arrangement, inductive power source 302 and power adapter 304 may be configured for wireless data communications as well as energy transfer based on authentication information thereby forming a trusted energy transfer arrangement. This trusted energy transfer arrangement is useful to prevent unauthorized

use of an inductive power source. Also the trusted energy transfer arrangement prevents a computer virus from infecting the smart controller 316 or the host device 100 via the information stores and data transmission pathways between the host device 100 and controller 316. Additionally, this trusted arrangement can prevent unwanted power from being transmitted to metallic objects, such as writing instruments, beverage cans and staplers, which may be placed in close proximity to a power source.

- [51] To start the process, in step 600, the inductive power source 302, in a low power or broadcast mode, polls for compatible devices through one or more of the power transmission coils 312 and listens for replies from the devices, such as power adapter 304. In step 602, in the listening mode, the power adapter 304, via controller 316, is configured to listen for a power source through the power pickup coil 324. Once the transmission coil 312 and pickup coil 324 are in close enough proximity to establish communications and inductive coupling, the communication signals received by the pickup coil 324 are de-modulated by the modem 308 and routed to the power adapter 304 controller 316. In step 604, the power adapter 304 may respond to the source 302 poll with a message requesting that power be supplied thereof. In step 606, upon receiving the power adapter's request for power, the inductive power source 302 may request for a security certificate or digital signature from the power adapter 304 to authenticate it. The security certification or digital signature may be stored in the computer readable storage of the controller 308. In step 608, if power adapter 304 has a certificate or signature, the power adapter 304 transmits it to the source 302. In step 610, if the power adapter 304 is authenticated, the source 302 supplies the requested voltage and power as shown in step 612. During the powering process, the source 302 may periodically poll the power adapter 304, and if no response is received or inductive coupling is removed, the source 302 changes state from the powering mode to return to the polling mode. In step 610, if the power adapter 304 is not authenticated, or the source 302 cannot supply the requested voltage or power, the source 302 may remain in low power mode, and the source 302 may return to polling mode. Nevertheless, steps any or all of steps 500-516 in FIG. 5 can be implemented in the process shown in FIG. 6.

Alternative Power Systems

- [52] An alternative the inductive power system 700 is illustrated in Figure 7. Inductive power system 700 components may include an inductive power source 702 that wirelessly provides electrical power to a power adapter 704. In the inductive power system 700, communications between the inductive power source 702 and power adapter 704 may be accomplished via an antenna and transceiver arrangement. A transceiver 705, 707 may be operatively coupled to an antenna 709, 711 for receiving and transmitting a wireless communication payload for both the inductive power source 702 and the power adapter 704. Any or all features and functions, subsystems shown in FIG. 3 can be implemented in the power system 700 shown in FIG. 7. For example, transceiver 705, 707 are respectively operatively coupled to a controller of inductive power source 702, and controller of power adapter 704, respectively. Power pickup coil 724 can receive inductive energy from the power transmission coil 712 of inductive source 702.
- [53] In one arrangement, a communications radio link 713 in accordance with the Bluetooth™ Global Specification for wireless connectivity may be implemented to transmit power information between the inductive power source 702 and power adapter 704. It should be appreciated that conventional Bluetooth™ technology was introduced to provide connectivity between portable devices like mobile phones, laptops, personal digital assistants (PDAs), and other nomadic devices up to a range of approximately 100 meters. Bluetooth-enabled devices operate in an unlicensed Instrumentation, Scientific, Medical (ISM) band at 2.4 GHz. This system uses frequency-hopping to enable the construction of low-power, low-cost radio devices with a small footprint. The Bluetooth-enabled devices transmit and receive on 79 different hop frequencies from 2402 to 2480 MHz, switching between one hop frequency to another in a pseudo-random sequence, 1600 times a second. The gross data rate is 1 Mb/s. A time-division duplex scheme is used for full-duplex transmission. In another example, a communication link 713 may be a widely available communication standard, such as the Infrared Data Association ("IrDA") specification and protocols. This wireless communication protocol provide

low-cost, short-range, cross-platform, point-to-point communications at various transfer rates for devices employing the standardize protocol. There are various suppliers of compatible hardware for transceivers and interfacing software modules to implement for the battery charger assembly 304 and inductive power source 302.

- [54] An example inductive power system 800 is illustrated in Figure 8. Inductive power system 800 components may include an inductive power source 802 that wirelessly provides electrical power to a power adapter attach to the host device 100 embodied as a laptop computer. It should be noted that any or all of the features, subsystems, and functions of inductive power source 302 and 702 may be included in the inductive power source 802. As shown in FIG. 8, the host device 100 is placed on a work surface 803 of a table 805. The work surface may have top surface and a bottom surface. In one arrangement, the inductive power source 302 can be physically mounted underneath the work surface 803 on the bottom surface. Alternatively, the inductive power source 802 may be disposed inside the work surface 803 so that the source 802 is generally recessed therein, e.g., slightly underneath the top surface. This configuration allows the source 302 to be located at a short distance from the power adapter for maximum efficiency of energy transfer and inductive coupling. Alternatively, the inductive charging source 302 may be placed on the top surface instead of being embedded. Nevertheless, multiple power sources can be provided on or with the work surface. This allows for multiple mobile devices to be charged in the same location. Thus, users with laptop computers or tablet computers can place the devices on the work surface and external power can be automatically provided to the power adapters. The users need not worry about the amount of power capacity in batteries or attempt to find an area to plug in the computer with power cords. This is particularly useful in working environments during long meetings when the mobile computers are used for electronic mail, typing, handwriting, web-browsing, presentations, data searching or other tasks. Further, while a work surface has been described, the inductive power source can be provided in a wide range of apparatus, including lecterns, desks, vehicles, and the like.

- [55] An alternative inductive power source 902 is illustrated in Figure 9. The inductive power source 902 wirelessly provides electrical power to a power adapter 304 (see FIG. 3) based on a regional proximity arrangement of transmission coils. It should be noted that any or all of the features, subsystems, and functions of inductive power source 302 and 702 may be included in the inductive power source 902 shown in FIG. 9. For example, inductive power source 902 is configured with power transmission coils 912 which are the same as coils 312 shown in Figure 3. In operation, the inductive power source 302 may listen for devices equipped with an inductive power adapter within proximity of at least some of the power transfer coils 912. The inductive charging source 302 may perform the polling operation in a sequential fashion, making each power transfer coil 912 an independent node. This independent node arrangement enables multiple devices to be powered by inductive power source 902. The multiple power adapters may have different power requirements which can be handled by the source 902. For example, a personal digital assistant has different requirements than a tablet computer.
- [56] With continued reference to FIG. 9, in one arrangement, an inductive power adapter, such as adapter 304, in range of the source 902 may wirelessly negotiate and transmit power requirements, such as maximum power rate (see FIGS. 5 and 6). Once the negotiation is complete, the inductive power source 902 may energize the coil 912 closest to the power adapter and inductively transfer power to the host device 100 in accordance with device requirements provided to the source 902. It should be recognized that the power adapter pickup coil and source power transfer coil 902 is referred to as the closest for regional proximity. The regional proximity arrangement can be implemented within source 902 by measurement of the strength of the inductive coupling between the power coil 912 and pickup coil of the power adapter. For example, when the power adapter is placed on the source 902, the controller and sensing circuitry within the source 902 can determine a load of the respective coil or flux density. This arrangement solves several safety drawbacks associated with high field inductive power systems and promotes the use of sophisticated mobile electronics with varying power requirements serviceable through a common inductive power source.

- [57] Referring to FIG. 3, in one alternative arrangement, inductive power source 302 may operate in a networked environment using logical connections to one or more remote computers, such as a remote computer 109 shown in Figure 1. The remote computer 109 may be a server, a router, a network PC, a peer device, or other common network node. The logical connections depicted in Figure 1 that can be implemented with inductive power source 302 may include a local area network (LAN) 112 and a wide area network (WAN) 113. Such networking environments are commonplace in offices, enterprise-wide computer networks, intranets, and the Internet. In a networked configuration, the inductive power source 302 is enabled to receive data associated with the power adapter 304, and transmit this data for trusted energy communications. For example, the remote computer 109 may be associated with a source entity that may retain data, such as power adapter ID numbers, serial numbers, manufacturer's names and date of manufactures of various power adapters. This information can be used for data integrity and security. Further, the source entity may include digital certificate information or a digital signature and transmit those items to the inductive power source 302 as requested. This data can be used as depicted in FIG. 6 for authentication for trusted energy transfer arrangement.
- [58] Inductive power arrangements provide user convenience by enabling wireless power to mobile computing devices and communications devices. To maximize the flexibility, efficiency and/or safety of these inductive power solutions, communication between the source and the devices may be established to exchange parameters and protocols. The communication may also provide for authentication of devices that are allowed by the source to be provided with power and devices placed in close proximity to the power source. This prevents virus infections and effectively closes a backdoor for computer viruses. There is no need to search for an electrical plug location that may be in inconvenient places. The hazards related to power cords are eliminated. There is no need to carry supplemental power battery packs to replace the depleted energy of a battery. And the inconvenience of carrying additional battery packs is eliminated. Thus, the mobile computing user receives the freedom for portable computing and protection from

computer viruses which may attempt to infect the power adapter controller or the coupled host device during data transmission or energy transfer.

[59] The foregoing detailed description has set forth various embodiments of the devices and/or processes via the use of block diagrams, flowcharts, and examples. Insofar as such block diagrams, flowcharts, and examples contain one or more functions and/or operations, it will be understood as notorious by those within the art that each function and/or operation within such block diagrams, flowcharts, or examples can be implemented, individually and/or collectively, by a wide range of hardware, software, firmware, or any combination thereof. In one embodiment, the aspects may be implemented via Application Specific Integrated Circuits (ASICs). Those, however, skilled in the art will recognize that the embodiments disclosed herein, in whole or in part, can be equivalently implemented in standard Integrated Circuits, as a computer program running on a computer, as a program running on a processor, as firmware, or as virtually any combination thereof and that designing the circuitry and/or writing the code for the software or firmware would be well within the skill of one of ordinary skill in the art in light of this disclosure.

[60] Although the invention has been defined using the appended claims, these claims are exemplary in that the invention may be intended to include the elements and steps described herein in any combination or sub combination. Accordingly, there are any number of alternative combinations for defining the invention, which incorporate one or more elements from the specification, including the description, claims, and drawings, in various combinations or sub combinations. It will be apparent to those skilled in the relevant technology, in light of the present specification, that alternate combinations of aspects of the invention, either alone or in combination with one or more elements or steps defined herein, may be utilized as modifications or alterations of the invention or as part of the invention. It may be intended that the written description of the invention contained herein covers all such modifications and alterations.